Adapting the Environmental Impact Statement Process to Inform Decisionmakers

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Abstract

The environmental impact statement (EIS) process is central to the assessment of environmentally significant actions. Yet decisions about what matters in the environment and what gets studied as part of an EIS are based on values that are largely implicit and come primarily from technical experts. In this article we propose using the techniques of decision analysis (DA) to articulate values explicitly and make the EIS process more effective as an aid to decisionmakers in developing defensible environmental policies. We identify five major sources of problems with the current EIS approach, propose a new environmental decision process that incorporates DA in the EIS framework, and consider the merits, problems, and feasibility of implementing the suggested policy improvements.

This year marks the 20th anniversary of the National Environmental Policy Act (NEPA), which mandated the environmental impact statement (EIS) process and thereby ushered in a new era of environmental management in the United States. NEPA specifies that an EIS analysis must be performed on all "major federal actions significantly affecting the quality of the human environment" so that the nation may "attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences" (Public Law 91-190, 1970). As recently described by the Council of Environmental Quality (1987), "The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment."

It is hard today to think of environmental management in the absence of the EIS process. However, criticisms of the current process have been frequent and strong, citing scientific, political, and ethical concerns relating to the types of information included in an EIS or the access that concerned parties are permitted [Orloff, 1978]. Battles over the content and procedures of EISs frequently make front-page news, and the reinterpretation of NEPA guidelines

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has been a favored topic of litigation throughout the 1970s and 1980s. Recent controversy over the suggested use of worst-case scenarios as a means for strengthening the EIS framework provides one prominent example of public interest in amending the current process [Masterman, 1989].

We believe that improvements in the EIS decision process are important and necessary. These improvements should address the need for environmental managers to have access to better information about public values, by which we mean the environmental values of potentially affected individuals.[1] Concern about the environmental effects of a proposed action is based on how the action will affect the welfare of society. Yet the typical EIS, although it is a multivolume treatise, rarely lives up to its mandate to consider "all reasonable alternatives to the proposed action" or to provide "a clear basis for choice among options by the decision maker and the public" [Council on Environmental Quality, 1987]. This mandate indicates the need to identify the best choice (in terms of minimizing environmental costs) by considering society's objectives and all relevant alternatives. This means that the EIS process is intended to address what is inherently a decision problem. However, the standard EIS framework is deficient as an aid to social decisionmaking: It addresses a particular proposed project, rather than the underlying problem, and it presents only a selected subset of the appropriate alternatives and impacts. As a result, decisionmakers cannot use an EIS as the basis for a defensible decision that properly reflects the complex public value tradeoffs among the objectives that characterize project alternatives.

The improvements suggested in this article are intended to make the EIS process more effective at two levels: first, as an aid to decisionmaking and policy development; second, as a means to facilitate implementation (when appropriate) of the proposed project. A key aspect of these improvements is to incorporate explicitly the environmental values of the individuals or groups (i.e., stakeholders[2]) concerned about an environmentally significant action and to separate clearly these value components from technical, factual assessments. Such an expansion of the EIS process can illuminate the principal sources of conflict, a necessary precursor to conflict resolution. The atmosphere of controversy, crisis, and bitterness that marks so many current resource development initiatives has little to do with meeting the technical requirements of NEPA and, to our thinking, is a predictable outcome of a decision process that largely ignores public values.

More comprehensive information about environmental values could be brought into the EIS process in several ways. One possible framework is cost–benefit analysis, which uses either actual or surrogate market prices as a mechanism for evaluating the relative worth of different environmental goods and amenities. A different framework involves using surveys of people's expressed attitudes toward alternative actions that lead to environmental consequences. In our view, neither of these approaches is appropriate: Cost–benefit techniques ignore or treat improperly many of the important unpriced consequences of an environmentally significant action [Gregory

[1] Throughout this article, the term "environmental values" refers to the values of individuals who might be affected by an environmental impact, rather than to ecosystem values (e.g., the watershed "value" of a wetland).

[2] A stakeholder group is defined as a group of people who, for any reason (e.g., place of residence, occupation, favored activities), share common values or opinions regarding a proposed project.

et al., in press], and surveys fail to provide information about value trade-offs that is necessary for defensible social decisionmaking.

We propose using the techniques of decision analysis to incorporate information about environmental values into the EIS process. Decision analysis (DA) is a systematic procedure to assist decisionmakers in making choices in the presence of uncertainty, risks, and conflicting objectives. It combines the judgments of technical experts, laypersons, and decisionmakers to construct an explicit model for evaluating the impacts of alternative actions. We therefore view the use of DA in the EIS process as a natural step toward improving the quality of environmental policy analysis by providing a decision focus to the EIS framework.

PROBLEMS WITH THE CURRENT EIS APPROACH

The current EIS approach focuses on the identification of impacts to the physical environment. It is therefore dominated by concerns of the physical sciences: biology, chemistry, ecology. This emphasis is unbalanced. Technical analysis is, of course, essential to understanding the important effects of a regulatory action. But the "importance" of effects is itself a value judgment [Dryzek, 1987]. Thus, someone's values about what matters in the environment determine what is and what is not studied as part of an EIS. At present, these values are largely implicit and come primarily from technical experts trained in the physical sciences. We believe that the values component of an EIS should be explicit and should be based on information that comes from affected and concerned individuals, including laypersons and members of key stakeholder groups as well as technical experts.

Of course, there is not just one way to do an EIS. Several researchers [e.g., Caldwell, 1982; Taylor, 1984] have noted that agencies have different requirements for what should be included, and that different situations call for a sensitivity to the collection and analysis of specialized data. In our experience, however, there are five sources of problems that often limit the applicability and usefulness of the EIS process as an input to defensible social decisionmaking: (1) inadequate consideration of alternatives; (2) narrow scope of impacts; (3) inadequate treatment of uncertainty; (4) poor distinctions between facts and values; and (5) limited public involvement.

Inadequate Consideration of Alternatives

An EIS is designed to evaluate a potentially beneficial course of action for society and the principal project alternatives. Generally a summary report takes the position that the proposed action is preferrred (and should be undertaken) because it meets a set of environmental and nonenvironmental criteria and does so better than any of the alternatives. However, if these criteria are incomplete, then impacts that are important to at least some of the potentially affected parties will not be represented. Contending projects should include any alternative that has a champion, meaning that at least one party concerned with the proposed action favors that project. In addition, each EIS should explicitly discuss the effort that was made to generate alternatives and the resulting alternatives identified. If any of these alternatives are cursorily dismissed from further consideration, the logic for dismissal should be presented for appraisal.

Many EISs fail to display these desired characteristics, or they present alternatives that appear to be constructed only so they can be dismissed, thereby appearing to add to the rationale for the favored action. For example, the Minerals Management Service EIS [1983] regarding lease sale 80, on the outer continental shelf off Southern California, provided substantial detail on the environmental impacts of oil production and transportation, but only brief discussions of the two proposed alternatives. The EIS prepared for a sour gas pipeline in Santa Barbara County [Little, 1988] proposes two alternatives to the pipeline: One is dismissed as incompatible with current land usage, and the second is a dominated alternative (equal risks and benefits, but higher cost).

Narrow Scope of Impacts

Most EISs focus on the direct environmental impacts of a proposed action and are project specific, addressing the question whether a particular facility should be built or whether a particular practice is likely to be environmentally damaging. In many cases, cumulative and indirect environmental impacts are likely to be an important public concern, yet they are rarely discussed in EIS documents.

Cumulative effects involve impacts that may not be important on an individual project basis but can be significant when examined in a larger geographic or temporal perspective, due to synergism (e.g., among pollutants emitted in the Los Angeles air basin) or due to the magnitude of the problem (e.g., the effects of global carbon dioxide emissions). For example, the environmental impacts of siting a pulp mill along a river may differ substantially depending on whether other mills operate or are planned along the same waterway. Because the individuals implementing an EIS typically have discretion over how it is conducted, cumulative impacts may not be considered, even though they appear to be of increasing concern to many U.S. residents. For example, the contribution to global carbon dioxide emissions resulting from expansion of coal-fired electricity generating capacity is a topic of considerable controversy and heated public debate.

Indirect effects are often difficult to assess because they occur in a geographically separated area or because they involve different sources of risk. For example, pollution mitigation measures to reduce emissions from a factory's stack may pose indirect health effects by increasing risks to workers in another state who manufacture the control equipment [Keeney and von Winterfeldt, 1986]. A decision to close a waste incinerator for fear of dioxin emissions may mean that the families of workers who lose their jobs will suffer from adverse health effects due to lowered income levels.

Inadequate Treatment of Uncertainty

Almost all environmental impact estimates are subject to uncertainty. Two sources of uncertainty are particularly important: event-based uncertainty and knowledge-based uncertainty.

Event-based uncertainty refers to a lack of data about the interrelationships among events. Statistical models are a great help in dealing with this uncertainty, but the limits inherent in these techniques are rarely addressed in EIS documents. For example, the rate of blowouts from offshore oil platforms is typically modeled by a Poisson process, but few EISs provide an explicit account of the uncertainty in the assumptions, in the parameters, or in the conditions as they apply to a particular situation. This point is important for integrating uncertain information, particularly across several different low probability–high consequence events.

Knowledge-based uncertainty refers to a lack of knowledge among experts about the impacts of an action on the environment. Examples include the health effects of low-level electromagnetic fields [Morgan et al., 1985] or the possibility of a one-in-100-years earthquake in an area where accurate records have been kept for only 75 years. Many policy analyses present a single "best estimate" along with a sensitivity analysis that brackets this estimate. For example, an EIS might state that "the likely impact of the proposed power plant will be an 8 percent decrease in fish populations, but it may be as high as 10 percent or as low as 6 percent." It is often not clear whether the range of estimates (e.g., 6–10% loss) is sufficiently broad (that is, why not consider a 2% or 50% loss?) to cover the desired distribution of cases from among those anticipated to occur.

Poor Distinctions between Facts and Values

An EIS typically is considered to be a document containing objective information about the environmental impacts of a project. In fact, numerous subjective judgments lie behind the choices that are made regarding impact identification, methods of analysis, and presentation format [O'Hare, 1980; Bobrow and Dryzek, 1987]. These judgments express the analyst's values, reflecting what is important to those conducting the study and what they believe should be included in an impact analysis. The specific information needs of affected communities and concerned groups are rarely considered as the basis for identification or detailed analysis of potential impacts. Instead, data are collected because they are easily available and thought to enhance the credibility of the analysis and the acceptability of a particular project. Data also may ignore important aspects of the social and cultural setting within which the impacts arise [Douglas and Wildavsky, 1982].

Limited Public Involvement

Environmental impacts always involve multiple stakeholders. In most cases, the various stakeholder groups will differ dramatically in their values and preferences about a proposed action affecting the natural environment [Gregory et al., 1989]. We believe that (1) it is important for this range of values to be included in the EIS process; (2) it is possible to elicit stakeholder values efficiently by sampling from a representative subset of interested groups [Edwards and von Winterfeldt, 1987]; and (3) it is essential that public values be reflected in the choice of impact topics considered as part of the EIS. However, most EISs respond to this diversity of concerns in a limited fashion [Orloff, 1978; Caldwell, 1989], often resulting in heightened public controversy and feelings of anger or outrage. Circulation of a draft EIS for public comments or solicitation of input at a public hearing, for example, will fail to quiet this controversy, because people recognize that they have not been informed sufficiently early in the assessment process to have their values and viewpoints count.

A PROPOSED DECISION APPROACH FOR THE EIS

The proposed approach merges the impact identification and evaluation objectives of an EIS with the decision focus of the decision analysis approach [see, for example, Raiffa, 1968; Keeney and Raiffa, 1976; von Winterfeldt and Edwards, 1986]. In the discussion that follows, we assume that a decisionmaker representing an agency has been asked to prepare an EIS to help select a decision that will be acceptable both within and outside the agency.

In previous work we have described an application of decision analysis to an important environmental problem, choosing a site for the nation's first high-level nuclear waste repository [Gregory and Lichtenstein, 1987; Merkhofer and Keeney, 1987]. This analysis was based on the results of five EISs, one for each site under consideration, and emphasized the use of judgments for the assessment of environmental impacts and values. The results were published by the Department of Energy [1986]; the national visibility of the problem, combined with the political sensitivity of the recommended site, resulted in unusual attention being given to the methods and recommendations of the report. However, the contribution of decision analysis to the repository evaluation was limited because the principal EIS documents were prepared prior to the start of the decision analysis. In addition, it has been argued that environmental impacts involving storage of radioactive wastes are unique political and policy problems because of the public's strong aversion to any level of radioactive exposure [Carter, 1987].[3] It thus seems useful to extend the discussion of decision analysis to the more typical situation in which an EIS is required.

We view the proposed approach as a five-task decision problem. Although we present the approach as a sequence, in any application there should be substantial iteration between the tasks.

Task 1: Structuring the Environmental Impact as a Decision Problem

This first task involves reorganizing the EIS process into the following five steps: (1) clearly defining the problem under consideration; (2) identifying a manageable number of stakeholder groups; (3) finding out stakeholder's objectives or attributes of value; (4) eliciting from stakeholders a set of alternatives to the proposed action; and (5) constructing explicit values hierarchies capable of distinguishing between general, intermediate, and specific environmental concerns.

Defining the problem under consideration requires the explicit recognition that the reason for the EIS is not to legitimate any particular proposal, but rather to improve social welfare through selection and implementation of the best solution to a given problem. Selecting the best option requires the involvement of stakeholders and the structuring of their objectives, which

[3] A reviewer has correctly pointed out that cases where the public exhibits strong emotions toward the siting of a facility or other environmental problems represent crucial tests of a method's ability to develop a defensible public consensus. We agree [e.g., see Keeney, 1980]; the unique aspect of the nuclear waste repository example is the high degree of intervention by Congress in designating Yucca Mountain, Nevada, as the facility location.

will provide the explicit statement of why anyone should care about the problem.

The second step is to identify representative stakeholder groups. Although a complete listing might cite 40 or 50 organizations, it is usually quite easy to identify perhaps 5 to 10 representative groups on the basis of the views that each organization holds and the constituency that it represents. Interaction with all stakeholder groups is seldom necessary, although it is important that the selection of stakeholder groups be made openly and that all major points of view be represented.

A next step is to schedule discussions with representatives of each group. These interviews would help the participants explicitly articulate the values that they believe should be used for environmental decisionmaking. Specifically, questions would ask about the values and concerns of the individuals; this information later will be structured and discussed with the interviewee for comments and used as the basis for preparing a common value tree. Structuring objectives and attributes requires the definition of specific values characterized by both an object (e.g., air pollution) and a direction of preference (e.g., less is better than more). For example, the objectives for a dam development may be to provide a steady municipal water supply, to achieve flood control, to minimize costs, and to minimize environmental impacts.

The next step is to create new alternatives; the objectives cited by the various stakeholders are used to identify desirable features. For example, commercial fishers involved in the consideration of offshore oil leasing plans in Southern California expressed great concern about compensation for gear lost due to an accident at an offshore production platform. Yet none of the alternatives introduced by the Minerals Management Service provided compensation for lost gear, despite the fact that this simple mechanism was relatively inexpensive and conceivably could have done much to gain the support of the fishing community.

The current EIS process considers alternatives, but typically stakeholders' environmental values are not used to define new alternatives. Two obvious alternatives always exist: the no-action alternative and the proposed alternative. Additional alternatives that provide different means to achieve the expressed objectives (e.g., placing a dam on a different river) often will be preferred by someone among the various stakeholders. In addition, mitigation alternatives that provide modifications to a proposed action (e.g., increasing the thickness of a dam) should be considered.

The current EIS process does consider objectives, but often they are represented so casually that careful analysis and weighting is impossible. In contrast, a DA-based approach would work directly with members of the different stakeholder groups to construct explicit "value trees" [Keeney and von Winterfeldt, 1987], which would distinguish between general, intermediate, and specific environmental concerns (a level of detail lacking in the output of more casual scoping sessions or focus groups). For example, a value tree may progress from a general concern with minimizing adverse environmental impacts, to an intermediate value such as minimizing water pollution, to a specific value such as minimizing the number of bass or brook trout killed. Attributes operationalize these values by providing a measurable scale. Health consequences, for example, may be measured in

Table 1. Objectives for evaluating nuclear waste repository sites.

Preclosure objectives
Health and safety
1. Minimize worker health effects from radiation exposure at the repository
2. Minimize public health effects from radiation exposure at the repository
3. Minimize worker health effects from nonradiological causes at the repository
4. Minimize public health effects from nonradiological causes at the repository
5. Minimize worker health effects from radiation exposure in waste transportation
6. Minimize public health effects from radiation exposure in waste transportation
7. Minimize worker health effects from nonradiological causes in waste transportation
8. Minimize public health effects from nonradiological causes in waste transportation
Environment
9. Minimize adverse aesthetic impacts
10. Minimize adverse archaeological, historical, and cultural impacts
11. Minimize adverse biological degradation
Socioeconomics
12. Minimize adverse socioeconomic impacts
Costs
13. Minimize repository costs
14. Minimize waste-transportation costs
Postclosure objectives
1. Minimize health effects during the first 10,000 years after repository closure
2. Minimize health effects during the period 10,000–100,000 years after repository closure

terms of a natural scale such as "number of deaths per year," whereas socioeconomic consequences may require a constructed scale that assesses key sources of possible community imbalance, stresses on infrastructure, and the like.

The objectives that were developed in the DA-based evaluation of five alternative high-level nuclear waste storage sites are presented as one example. In this case, values were structured based on the review of published positions and comments and based on discussions with DOE managers, staff, and contractors. This process was not ideal in that interviews with all key stakeholders were not conducted, but the analysis was constrained by the contractor and some knowledge of stakeholders' values was already in hand from earlier studies. The final set of sixteen objectives, listed in Table 1, emphasizes health effects and separates them into preclosure and postclosure effects, following regulations set forth by the

Environmental Protection Agency. Twelve natural scales were used (measuring costs, preclosure worker and public fatalities, and postclosure radiation emitted) and four scales were constructed (to measure aesthetic impacts, biological degradation, archaeological and cultural impacts, and socioeconomic effects).[4]

This example also demonstrates how reference to stakeholders' values will help to construct a full set of mitigation alternatives. This is because their creation requires looking beyond bounds that may have been artificially placed on a project. In the study of nuclear waste transportation options, for example, the original set of mitigation alternatives included only concerns such as different casks or different modes of transportation. Discussions with stakeholders suggested a wide range of different mitigation options, such as training safety crews or providing insurance and compensation mechanisms in case of an accident [Keeney, 1988].

Task 2: Estimating Uncertain Impacts

This portion of the revised EIS process would use expert judgments to estimate impact magnitude and likelihood, based on the set of impacts identified by stakeholders as important. Experts would be selected and, in some cases, trained to develop quantitative estimates of impacts, based on whatever models and data were available or could be collected [Merkhofer, 1987]. If possible, they would be brought together as a group to discuss the nature of the judgments they have to make and to review alternative ways of decomposing the task. For example, when examining the impacts of a proposed dam development on the local economy, the experts may wish to decompose their judgments by considering alternative regional economic scenarios and attaching probabilities to each.

Uncertainty can enter the impact evaluation process because of uncertainties about possible future external events or because of limited expert knowledge. Uncertainty about events can be incorporated and represented to decisionmakers by using decision trees [Morgan and Henrion, 1989], which lay out the sequence connecting impacts with the probabilities of intermediate events, or by using influence diagrams [Shachter, 1987], which mirror the thinking of experts by showing how variables are connected in a causal or sequential manner. Both techniques make use of skills already familiar to most analysts and are intuitively attractive.[5] Uncertainties due to knowledge limitations can be incorporated by asking experts to define the plausible maximum and minimum levels of an impact and to describe the probability distributions, over the impacts or over a set of decomposed quantities, used for making impact estimates. It also may be important to examine the relation

[4] All natural scale utility functions were determined to be linear. Utility functions for the four constructed scales were obtained by eliciting 0–1 ratings between the least and largest impact levels. Value trade-offs—for example, between a public fatality and a worker fatality—were established during interviews with the same group of managers. No value trade-off was made between the preclosure and postclosure scales; instead, the trade-off was parameterized in the aggregate utility function and subjected to sensitivity analyses.

[5] Both influence diagrams and decision trees are ways to model a decision problem and, as such, are part of many analysts' training. However, further guidance in their use would be required in some cases. For example, influence diagrams are often confused with flow charts, but they serve a different purpose because they look at the structure of a decision at a single point in time.

between the uncertainty of impact occurrence and psychological factors that have been shown to affect perceptions of the risks of a proposed facility; for example, the existence of ambiguity aversion appears to contribute to concern and worry about some types of project initiatives [Hogarth and Kunreuther, 1989].

Task 3: Assessing Value Trade-offs and Constructing an Acceptable Value Model

The next task in the proposed approach is to evaluate trade-offs across impacts. Many methods exist for performing this evaluation, including cost–benefit methods and multiattribute utility techniques. The use of current methods, which attempt to balance the costs and benefits of different goals in establishing priorities, has been described in some detail by numerous authors [e.g., Taylor, 1984; Portney, 1990]. We believe that multiattribute methods are particularly well suited to the decision requirements of many emerging environmental problems and that their adoption would lead to an improvement over current practices because values hierarchies would be more explicit and measures of critical objectives would be more clearly structured.

Specifically, the proposed approach consists of two principal steps. The first step is to assess single attribute utility functions, which rescales the attributes of values to reflect the relative desirability of different attribute levels. This requires consideration of both the direction and the shape of the utility function. For example, assessment of the environmental attribute "percent permanent reduction of fish population in river X" would require an agency or stakeholder representative to express both a direction (e.g., larger percentages are less preferred) and the relative desirability among scale levels for this attribute (e.g., is the step from 0% to 25% more or less undesirable than the step from 25% to 50%?) [Keeney, 1977].

The second step requires assessing value trade-offs among attributes to construct an overall value model. Assessing how stakeholders want to make value trade-offs indicates how many units of one attribute are worth how many units of another attribute. For this purpose, analysts might ask questions designed to determine what percentage increase in community unemployment is acceptable in exchange for a 20% decrease in health effects from smokestack emissions. Such questions are difficult to answer, but trade-off issues must be addressed either implicitly or explicitly as they are inherently part of the problem.

Construction of the overall value model requires that a decision be made about the form of the multiattribute utility function [see von Winterfeldt and Edwards, 1986]. Often the additive utility function, in which the single attribute utility functions are multiplied by their respective weights and added across attributes, is reasonable. In the nuclear repository study, for example, single attribute utility functions were constructed in interviews with nuclear waste managers. Discussions with these managers verified that a simple additive aggregation of the component utility functions was appropriate. This resulted in the calculation of overall expected utilities and equivalent dollar costs for the five sites (when impacts are uncertain, expected utilities can be calculated over the probability distributions characterizing the impact of each alternative).

These value models can be very informative. For example, past experience suggests that stakeholders will agree on the main value categories but differ in the level of detail to which they develop particular categories and the weights that are assigned to values at upper levels of the common value tree. Disagreements between stakeholder groups about the appropriate value trade-offs will then serve as a clue to where sensitivity analyses might lead to different rankings of the project alternatives under consideration.

Task 4: Evaluating Alternatives in Light of Values

Evaluation of the alternatives begins with the analyst combining each stakeholder's value model with experts' estimates of possible impacts. Formally, given the aforementioned utility functions, the analyst computes

$$u(A_j) = \sum_{i=1}^{n} w_i u_i(a_{ij}), \tag{1}$$

where $u(A_j)$ is the overall utility to the stakeholder of alternative j, w_i is the weight of the i-th impact attribute ($i = 1, \ldots, n$), u_i is the utility function of the i-th attribute, and a_{ij} is the impact estimate[6] of alternative j on attribute i. Sensitivity analysis is carried out to assess the implications of differences in the assessments of the a_{ij}'s or probability distributions made by technical experts, as well as differences in weights or utility functions representing the values of different stakeholders. The results of sensitivity analyses help analysts and stakeholders recognize those aspects of the problem that matter and those that do not. This knowledge should then be used to generate new alternatives that will aid the decisionmaking process.

In the nuclear waste storage study, sensitivity analyses were conducted to test directly numerous assumptions about (1) possible impacts and the probability of their occurrence; (2) value trade-offs between the objectives, such as between socioeconomic and aesthetic or biological impacts; (3) the forms of the utility functions and aggregation rule; and (4) value trade-offs between preclosure (i.e., prior to closing the respository) and postclosure impacts. The results for this problem were remarkably stable, due in large part to the strong influence of the cost factors, the large correlation between health and cost impacts, and high expected postclosure performance at all sites.

Sensitivity analyses also are useful to identify discrepancies between the models of stakeholder values and peoples' intuitive preferences. Based on previous studies, we anticipate that this aspect of the decision process, combined with the iterative nature of the analysis itself, will usefully stimulate thinking about the limitations of one's intuition as well as the bounds of the modeling process.

Task 5: Presenting Information to Decisionmakers

The final task for any EIS approach is to present its results to decisionmakers so that they understand the implications and make use of the analysis to

[6] Whenever the a_{ij}'s are uncertain, the last term of eq. (1) would be replaced by the expected utility of the probability distributions over single attribute impacts.

present and defend recommended actions. The conventional EIS process fails to achieve these goals because its focus is collecting factual information rather than aiding policy decisions. The proposed assessment approach speaks directly to three important needs of environmental policy decisionmakers.

First, decisionmakers need to understand the technical dimensions of a project and its likely impacts on the human and natural environment. Thus factual information must be set out clearly, with accessible distinctions made regarding the magnitude of different impacts and their likelihoods.

Second, decisionmakers need to understand public concerns so they can anticipate the questions that will be asked of them and address these as part of the evaluation process. Some of these concerns will relate to the outcomes of a decision, but other concerns will relate to the process by which that decision is made, e.g.: How were agency priorities set? Why was a particular strategy for analysis selected? How were value trade-offs made between key attributes of competing alternatives?

Third, decisionmakers need to be able to defend their choices within existing institutional and political frameworks. Involving stakeholders' values in a meaningful way requires a sharing of power that will increase credibility with the public but that some institutions may be loath to permit. In addition, some of the value trade-offs made as part of the analysis could prove unpopular. For example, additional monetary expenditures can almost always decrease the health risks of a potentially hazardous facility. In the face of public demands for zero risk, necessary value trade-offs that are made between cost and safety are likely to be controversial. The decisionmaker will need to anticipate these objections and argue that the EIS is only making explicit implications that otherwise would likely remain relatively hidden.

SUGGESTIONS FOR IMPLEMENTATION

The current EIS process has been in place for 20 years. Incremental changes have been made throughout this time, as noted earlier, but the basic philosophy behind EIS preparation has remained constant: Provide a document that will satisfy the legal requirements of NEPA and the scientific requirements of technical impact analysis. The operative notion has been that decisionmakers will be able to defend their decisions providing they can meet the law and have sound technical information in hand.

Reality presents a different picture. The siting and construction of a large and diverse group of socially beneficial facilities—including landfills, resource recovery plants, offshore oil and gas facilities, waste water treatment plants, expressways, transmission lines, and hazardous chemical storage sites—have been opposed by citizen groups and local government agencies partially because of perceived deficiencies in the EIS process [Taylor, 1984]. Problems typically arise when key parties believe that their interests and concerns are not being considered. In such cases decisionmakers are often caught between the analysis in hand, which meets the formal requirements of the EIS process as outlined in NEPA, and the demands made by constituents or in-house experts to look more closely at different sources of values, different project alternatives, and different decision processes.

There are both methodological and institutional barriers to the acceptance of an improved framework for environmental decisionmaking. Bureaucracies move slowly, and the current EIS process has developed a life and traditions of its own that perhaps are based as much on the tactics of adversarial lawyers as on the prescriptions of federal legislation [Bardach and Pugliaresi, 1977].[7] The proposed techniques should have some success in surmounting these barriers, provided that they capture the attention and approval of environmental policy analysts. Shifts in public attitudes and opinions toward environmental protection and the quality of life [Inglehart, 1989] have created an impetus for change in the rationality used to evaluate government funding and development options, thereby creating an opening for new decisionmaking procedures to guide environmentally significant choices.

The proposed merging of decision analysis into the EIS process can be successful only if the fundamental distinction between facts and values is recognized as relevant to the legally defined EIS process. Once this is done, the focus of the effort necessarily will shift: Technical experts will still be essential for providing factual information, but the relevant affected individuals and concerned groups will be asked to provide information about the values that matter in structuring objectives and identifying alternatives.

Admittedly, values could be elicited at some other stage in environmental decisionmaking, outside of the EIS process; on several occasions, scientists now active in conducting EISs have made the argument that additional public involvement would needlessly complicate the EIS process. However, we believe that using public values to structure the selection of impacts and to generate alternatives is important, both because the content of an EIS could be affected (e.g., new alternatives or new objectives might be considered) and because the potentially affected individuals would gain a stronger and more visible voice in the process of impact evaluation.

Two fundamental issues might hamper the use of decision analysis in the EIS context. These issues concern the ethical basis and assumptions of decision analysis and multiattribute utility theory as a technique for improving social decisionmaking [Keeney and Raiffa, 1976].

A first concern is that decision analysis techniques make certain assumptions about the structure of values and preferences that may prove difficult or puzzling to some individuals. For example, decision analysis makes firm prescriptive demands such as "Disregard regret!" and "Treat ambiguity as you would any other kind of uncertainty!" [Lichtenstein et al., 1990]. Further, the value models used in decision analysis are constructed in a manner such that, if one accepts a set of logical principles to guide the decision at hand [see, for example, von Winterfeldt and Edwards, 1986], the expected utility derived for each alternative is an indication of its relative desirability. Some people might question this procedure (which concludes that an alternative with a higher expected utility should be preferred to one with a lower expected utility) because they question the assumptions of expected utility theory [e.g., Sagoff, 1988] or because they question the relation of an explicit value function to their preferences [e.g., MacGregor and Slovic, 1986]. Others may question the subjectivity of the value models, believing that early steps in the conduct of a decision analysis could be influenced by the analyst to be consistent with a specific ethical position or theory of justice (e.g., libertarian-

[7] As stated by Bardach and Pugliaresi [1977, p. 24], "Agencies cannot be penetrating or creative when their analyses are directed and mobilized for primarily defensive purposes."

ism or egalitarianism) [Keeney, 1984; Merkhofer, 1987]. We do not disagree with this as a concern, although we note that in our opinion the difference between DA and other methods for determining public risks and benefits is not in their relative degree of subjectivity, but in the extent to which necessary subjective judgments (e.g., value assumptions) are made explicitly for review, communication, and appraisal.

Second, the use of decision analysis is a political statement about the substance and process of evaluating environmental impacts. An approach based on decision analysis would employ expert judgments to develop estimates of impact magnitudes and likelihoods, but it also would, from the start of the EIS process, elicit input from representatives of key stakeholder groups in identifying impact classes, in structuring objectives, and in developing management alternatives [Gregory, in press]. The current EIS process, in contrast, typically involves stakeholders either informally (e.g., as invitees to public hearings) or at the end of the project evaluation process, which in our view makes it difficult to incorporate new objectives or new alternatives into the decisionmaking structure. Thus, we recognize that the use of decision analysis is a potentially controversial political and cultural choice about the role of analysis in government decisionmaking and about who should be involved in environmental policy decisions [Yandle, 1989]. However, we believe that by bringing values into the picture at the beginning of the evaluation process, the nature of the information provided by the EIS is improved and so is its access. As a result, the potentially affected public, and not solely experts selected by the developer or regulatory agency, would play an important role in selecting and monitoring the targets of the evaluation.

With the explicit use of values would come a change in the outputs of an analysis. The products of an EIS designed to inform decisionmakers will outline what is important to people and define the value trade-offs that stakeholder groups are willing to make among these attributes. The initial products of the revised EIS, therefore, would include a list of stakeholders, a list of their relevant objectives and attributes to measure them, and a combined value tree to integrate the values of individual groups.[8] Single attribute utility functions and weights would be shown along with the aggregate utilities. Finally, the results of sensitivity analyses would be presented to test explicitly the influence of changes in key assumptions, judgments, and data.

Conceptually, the range of impacts under consideration can be broadened to include cumulative effects, indirect effects, and anything else that (1) helps to distinguish among the alternatives; and (2) is considered to be important by any of the stakeholder groups. The concepts used to analyze cumulative and indirect effects should be easily understood by people with little analytical knowledge. Decision trees, for example, can provide a simple structure for representing the accumulation of actions and events, beginning with the initial alternatives but adding future actions and events that constitute cumulative effects. Influence diagrams can provide a map of experts' current state of knowledge about key casual relationships and interactions. The fact that these tools are intuitively attractive and easily understandable will help analysts adopt the proposed techniques and help decisionmakers, given the

[8] If uncertainty in the estimation of impacts is considered critical, an alternatives-by-attributes matrix also should be presented that summarizes (using point estimates or distributions) the probabilities attached to each impact estimate.

opportunity, to accept these changes in the environmental impact assessment process.

Another advantage of the proposed approach is that it can help to ascertain how much information is needed to reach a defensible policy decision. Formal techniques exist for assessing the value of different information and its economic costs [Holloway, 1979]. Because data are useful to the extent that they are able to lead to clearer distinctions among the alternatives, some information on impacts will be identified as not worthwhile to collect (and therefore not worth spending money on) because it could not alter the decisions to be made.

Information can be presented to decisionmakers at different levels of aggregation, depending on the level of detail desired and the importance of the decision at hand. For many cases, decisionmakers need only know about the basic structure of the problem (the alternatives, attributes, and combined value tree) and the aggregated utilities. This information usually can be presented in a document of 10–30 pages. If more information is required, the capability will exist to move to a lower level of aggregation (i.e., the secondary objectives).

This proposed approach requires skills that are within the capabilities of most current analysts, although more complex assessments (e.g., those potentially involving large-scale changes in the physical or sociocultural environment) will continue (as now) to require the use or development of specialized techniques. The products of the approach will be more useful to a decisionmaker than are those of the current EIS process. The identification of stakeholders, a key element in the suggested revision, is critical for understanding the scope of a problem (what must be considered in an EIS) and for outlining objectives and alternatives. Dominated alternatives will be screened out early, which saves time (for the analyst and the decisionmaker) as well as money. Objectives will be operationalized by identifying attributes, so that the clarification of diffuse or confused goals can occur early in the evaluation process. So will the clarification of a confused decision process: Although some technical aspects of the analyses may remain a mystery (e.g., Bayesian revision of probabilities), the principles and basic building blocks of the decision framework can be described sufficiently clearly that they are easy to understand.

Implementation of the proposed EIS/DA framework may proceed most surely if the suggested stronger role for information about values in the decision process is viewed as refining existing elements of traditional EIS procedures. It is highly unlikely that any procedure viewed as a stark alternative to current EIS practice will be adopted; existing players—including physical scientists, lawyers, and government decisionmakers—would too strongly fear their losses. Instead, the proposed values-structuring process could begin in parallel with current, "facts-based" EIS procedures. The proposed approach then would be viewed not as an alternative to the existing EIS process but rather as a means for structuring it: prestructuring, in the sense of initially identifying alternatives and objectives; aggregating, in the sense of systematically searching across data on environmental impacts to account for synergistic effects and for uncertainty; and summarizing, in the sense of identifying key, values-based sensitivity analyses and providing information to decisionmakers at several layers of detail.

CONCLUSION

The proposed EIS/DA framework for environmental assessment is sensible, doable, and an improvement over current practice. We believe that the techniques and procedures required to integrate technical information about environmental impacts and stakeholder information about environmental values exist. However, the incorporation of some concepts of decision analysis into the EIS process requires not only a change of skills but a change of heart: Analysts accustomed to having a great deal of discretion in decision structuring must learn to share that power with the public; analysts accustomed to making implicit choices must make explicit trades; and analysts accustomed to building models of biological processes must recognize the importance of modeling social values.

We believe that the basic structure of decision analysis is appropriate to facilitate environmental decisionmaking and that the tools of the approach are both intuitively attractive and easily understandable. In our opinion, decisionmakers will find the approach helpful and will participate in its further evolution. Existing legal and bureaucratic forces will create obstacles, as is to be expected whenever change comes to an established practice. However, with the insistence and support of environmental policy analysts, a far improved policy for conducting evaluations of environmental impacts could be set in place.

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